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Nonpoint Source Pollution from Agricultural Runoff: An Analysis of Problems, Solutions, and the Remedial Action Plan Process for the St. Louis River Basin

Thomas V. Giddings
University of Rhode Island

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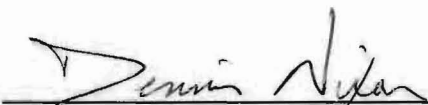
**Nonpoint Source Pollution From Agricultural Runoff:
An Analysis of Problems, Solutions, And The Remedial
Action Plan Process For The St. Louis River Basin**

By
Thomas V. Giddings

*A Paper submitted in partial
fulfillment of the requirements for the degree of
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Professor Dennis Nixon

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I: Introduction:

Agricultural nonpoint source pollution is the pollution coming from agricultural production, which has no clear origin. It comes from a diffuse source, such as a farm field or an animal holding area. It is not a new problem, yet nonpoint source pollution from agricultural related activities has not been given the necessary attention it deserves. While programs and studies probe every facet of point sources and extol the efforts of point source clean-up, the relatively more difficult task of identifying nonpoint sources and the process of proposing to do something about them has been largely ignored. The question must be asked, *is the nonpoint source pollution problem that difficult to solve?* While this may be an overly broad question, in the case of nonpoint source pollution from agricultural activities, the answer, and certainly the work necessary to produce better answers may not be as difficult as some would believe.

Reducing the adverse impacts on the environment from farm related activities requires knowledge of the various pollutants and how pollutant pathways can be interrupted. To what degree is agricultural nonpoint source pollution a problem? A study of "nonpoint-source loading" by the National Commission on water quality projected nonpoint sources (mainly agriculture) will produce 72,500 tons per day of suspended solids, 14,150 tons per day of nitrogen, 965

tons per day of phosphorus, as well as most of the remaining fecal coliform pollution, even after all point sources are remedied.¹ Nonpoint source pollution in Minnesota has seriously affected many lakes and rivers. Considering only waters not supporting designated uses, 2,107 river miles are affected by nonpoint source pollution as opposed to 783 river miles affected by point sources; in lake acres, 172,449 acres are affected by nonpoint sources as opposed to 64,396 affected acres attributed to point sources.² Nutrients, sediment, and pesticides enter surface water through runoff. Nutrients, and pesticides leach through the soil contaminating ground water supplies. Animal waste adds nutrients and bacteria to the water column, and erosion carries with it what runoff doesn't wash away. Even so, little effort is made to identify the problem and even less is done to implement best management techniques that would mitigate the problem. This is especially true along the Minnesota-Wisconsin coast of Lake Superior, and in particular the St. Louis River basin. While tremendous work has been

¹ United States Department of Agriculture and the United States Environmental Protection Agency, The Rural Clean Water Program: A Report (Washington GPO, 1989)

² Minnesota, Pollution Control Agency, Agriculture And Water Quality. Best Management Practices For Minnesota (St Paul: Pollution Control Agency, 1989;1991) 2-3.

accomplished in identifying and cleaning up point sources, very little has been done to identify nonpoint source pollution from agriculture, or to implement best management practices in an overall water quality plan.

II: The St. Louis River:

Particular concern must be given to protecting the Minnesota-Wisconsin coast of Lake Superior, specifically the St. Louis River basin. The St. Louis River is the second largest tributary to Lake Superior. The area supports a wide variety of activities both recreational and commercial. The river's 66 cubic meter per second mean annual discharge is exceeded only by the Nipigon River.³ Its watershed consists of 3,634 square miles in northeastern Minnesota, and 263 square miles in northwestern Wisconsin.⁴ From its headwaters at Seven Beaver Lake, the river flows 179 miles in a southwesterly direction to Lake Superior. As the River approaches the city of Duluth and Superior, it takes on the characteristics of a freshwater estuary. The upper portion of the St. Louis River is characterized by narrow, deep channels with depths ranging from 10 to 30 feet. As the river flows westward across St. Louis County, it passes through forested areas of sand, gravel, clay glacial till and outwash deposits. From the town of Floodwood to Thomson, the river passes through very hilly wooded glacial moraine. The soils in this area are course-loamy fine sands, loamy

³ Minnesota Pollution Control Agency; Wisconsin Department of Natural Resources, The St. Louis River System Remedial Action Plan Stage I, Minnesota Pollution Control Agency; Wisconsin Department of Natural Resources, 1992) III-1.

⁴ Remedial Action Plan III-1.

mantles, and sands and gravel interspersed with some fine loam.⁵ In this area valley slopes increase in size and steepness along the river banks. Below Thomson, the River abruptly changes as it flows through the deep narrow gorge of Thomson slates and conglomerate rounded pebble and sand rock formations of Jay Cooke State Park in lower Carlton County.⁶ The final reach of the St. Louis River drains through the red clay deposits of glacial Lake Duluth and enters the St. Louis Bay estuary.

Figure 1

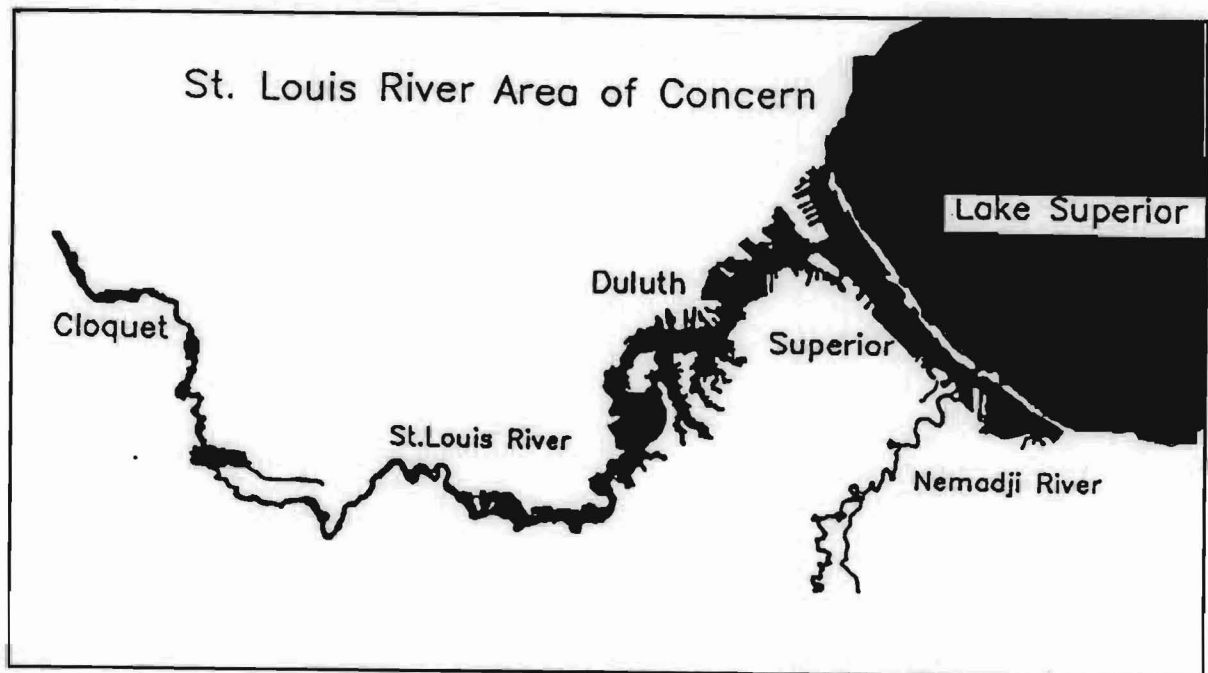


Source: The Software Toolworks U.S. Atlas, version 3.1.0, computer software, The Software Toolworks, Inc., 1991-1992, MS-DOS, disk.

⁵ Remedial Action Plan III-3.

⁶ Remedial Action Plan III-3.

Figure 2



Source: Minnesota Pollution Control Agency; Wisconsin Department of Natural Resources, The St. Louis River System Remedial Action Plan Stage I, Minnesota Pollution Control Agency; Wisconsin Department of Natural Resources, 1992.

The Nemadji River, which also drains into Superior Bay, and is part of the St. Louis River watershed, encompasses 360 square miles.⁷ The Nemadji River system starts five miles east of Moose Lake and flows north to the Atkinson area and east through southeastern Carlton County, Minnesota. It then flows northeast in to Douglas County, Wisconsin where it enters Superior Bay. This area, and Lake Superior itself are among Minnesota's most valuable resources, and represent in clear terms the net effect of considerable attention to point sources, and neglect of nonpoint sources from agriculture.

⁷ Remedial Action Plan III-4.

An examination of land use and the possible sources of nonpoint source pollution contributing to the water quality degradation of the St. Louis River and Lake Superior indicates that agriculture may be among the most significant contributors in the St. Louis River basin. While the northeastern portion of Minnesota and Wisconsin are not as agriculturally intensive as other portions of the State, a significant amount of acreage is devoted to agriculture. Total cropland acreage in the St. Louis River basin is divided primarily between three counties; Carlton County which has 66,492 acres devoted to agriculture, St. Louis County which has 93,438 acres, and Douglas County Wisconsin which has 26,826 acres.⁸ A more quantifiable, and perhaps more telling statistic is the number of dairy farms in lower St. Louis County; 69, and their location; 95 percent are located directly on the St. Louis River or its tributaries.⁹

The St. Louis River Basin, including the Nemadji River, has a long and documented history of degradation and neglect as a result of point source pollutants impacting water quality. A 1928-1929 investigation by the Minnesota State Board of Health classified the portion of the river which runs from the city of Cloquet to Lake Superior as

⁸ Remedial Action Plan V-36.

⁹ Remedial Action Plan V-36.

"pollutional".¹⁰ A follow-up study in 1948 reaffirmed the findings of the earlier study, and further added that, in the ensuing 20 years that had elapsed, there had been a significant increase in waste discharges with no corresponding increase in treatment.

Figure 3



Source: The Software Toolworks U.S. Atlas, version 3.1.0, computer software, The Software Toolworks, Inc., 1991-1992, MS-DOS, disk.

Complaints of tainted fish flavor and fish kills continued through the 1970's. Waste water treatment improvements in the 1980's helped ease the heavy pollutant

¹⁰ Remedial Action Plan ii.

load, particularly total phosphorus. Problems with toxic residues in fish, however, persisted as late as 1985. In addition to historical discharges that have contributed mercury, PCB's, dioxins, and polynuclear aromatic hydrocarbons (PAH's) that now contaminate sediments, there are continuing contributions from industrial and municipal discharges, as well as a significant number of landfills.

Prior to settlement in the nineteenth century, the St. Louis River watershed was dominated by coniferous boreal forest, consisting mainly of white pine, spruce, fir, and red pine. Extensive clear-cut logging in the late nineteenth and early twentieth century significantly altered the hydrology of the watershed. Subsequent fires eliminated the 2-4 inch "duff" top soil layer important in retaining moisture, and further changed watershed hydrology. The area was eventually cleared for agricultural use, and remaining woodlands grew back as an aspen, maple, spruce, and fir cover. This change dramatically increased the runoff associated with storm events, and seasonal peak flows. Further land smoothing and drainage activities associated with agriculture and urbanization have increased runoff rates.

While the many point source inputs are well defined, little quantitative information exists for the significant accumulation of nonpoint source pollution delivered to the St. Louis River. No systematic attempt has been made to identify or address groundwater contamination despite the

existence of a number of contaminated sites. Where action has been taken, it has been of a highly localized nature. The significance of surface runoff as a transport mechanism is poorly identified within the watershed despite serious sediment loading problems where the River forms Superior Bay and empties into Lake Superior. The significance of the sediment loading is demonstrated by the 150,000 to 200,000 cubic yards dredged from the Duluth-Superior Harbor each year at a cost of \$7.00 per cubic yard.¹¹ Nutrient content has been analyzed in relation to waste water treatment plant discharges, however information on nutrient input from agricultural activities which are much more concentrated is lacking. In addition, while information concerning pesticide and insecticide characteristics is available, correlation with those in use within the area has not been addressed.

¹¹ Remedial Action Plan iv.

III: Identifying the problem:

A critical first step in identifying the process of generating nonpoint source pollution is a potential pollutant's means of detachment, and the means by which a pollutant is transported to the water body. Detachment is the release of a pollutant which may be either chemically or physically bonded to the soil particle. In some cases the pollutant is dissolved in water, and detachment will be from the point of application where it becomes dissolved. In other cases soil particles are detached as erosion. Transport of a pollutant is the movement of a pollutant from its origin to a water body. The pollutant need not have reached its end point or point of integration to begin having an adverse effect on a water body. It may be a pollutant in the transport system which will have a negative impact on the aquatic environment. When a pollutant finally becomes integrated into an ecosystem, it may be as an attached pollutant to a sediment particle, or dissolved into the water column.

The availability of a potential pollutant, and its detachment and transport will depend on a number of characteristics. Generally these characteristics are: (1) physical properties, (2) chemical properties, and (3) reactivity and biological properties of the pollutant. Pollutants which are strongly adsorbed by the soil are more susceptible to detachment and transport with the soil. Those

pollutants which are less adsorbed, and more soluble are much more likely to leach through the soil affecting ground water supplies. Examples of this are biological denitrification of nitrate to nitrogen gas which can reduce the nitrate concentration of a stream or lake, nitrification of ammonium (NH_4) adsorbed on a soil particle which will increase nitrate levels in the water body, and phosphates adsorbed on a soil particle which can be released into solution when it enters a lake with a low dissolved phosphate concentration.

For a management practice to be effective in interrupting the pathway of pollutants from a diffuse source, it must be able to interfere with the availability, detachment, and transport of a pollutant. A practice must be able to decrease availability, prevent detachment, or interrupt the transport process in order to decrease the pollutant load. In selecting a means to accomplish this both the degree of capital investment and the overall management practices required of an agricultural producer must be considered. Practices that require a high degree of capital investment will be unattractive to the producer, and therefore will, in most cases, not be implemented. Low cost methodologies may be more attractive but may require a much more time intensive effort than the producer is willing to commit to. It is also important to realize that not all practices are right for every water quality problem. If a practice fails to control the target pollutant than it can

hardly be considered a "best management practice". Selecting the best management practice then is as important as identifying the pollutant or establishing the pollutant's pathway.

The primary nonpoint source pollutants from agriculture can be grouped into the following categories: nutrients, sediments, animal waste, and pesticides. A possible fifth pollutant which will not be addressed are salts. Each present their own set of effects within the water column, and unique best management practices.

Nitrogen and phosphorus are the two major nutrients from agriculture that contribute to decreased water quality. Background levels in an aquatic environment are approximately 0.3 mg/l for nitrogen and 0.05 mg/l for phosphorus.¹² When nitrogen and phosphorus are introduced into an aquatic ecosystems, plant productivity can dramatically increase. Increased plant productivity results in additional organic matter being added to a water body. As plant material eventually dies, the decay process depletes the oxygen level, and can potentially produce unpleasant odors. Depleted oxygen levels, especially in colder bottom waters will change fish and aquatic plant habitat, often resulting in algae blooms and consequently increased turbidity.

A water body is classified by the nutrient level it

¹² United States Department of Agriculture Soil Conservation Service, Water Quality Field Guide (Washington:GPO, 1983) 7.

contains. This classification is referred to as the trophic level. Oligotrophic water bodies exhibit the least degree of biological productivity, with the primary limiting factors being nitrogen and phosphorus. They are characterized by clear water (high degree of transparency), relatively uniform distribution of dissolved oxygen, and small amounts of decomposed organic matter. Lake Superior is presently classified as Oligotrophic.

Eutrophic water bodies represent the opposite end of the spectrum. They are characterized by a high degree of biological productivity, an over abundance of nutrients, and dissolved oxygen levels that are subject to wide variation. The excess biomass generates abundant dissolved oxygen during the photosynthetic process. When the process is interrupted, dissolved oxygen levels may fall to nearly zero as oxygen is used.

Eutrophic conditions represent only one possible result of excess nitrogen. Dissolved ammonia at concentrations above .2mg/l can be toxic to fish populations. Ammonia (NH_4^+) in the soil readily breaks down into nitrites (NO_2^-) and ultimately into its most useable plant form, nitrates (NO_3^-). Nitrates in drinking water pose a serious health threat to humans, particularly infants. Nitrates are converted back to nitrites in the digestive tract, reducing the oxygen carrying capacity of the blood (methemoglobinemia). This can result

in brain damage or even death. The Environmental Protection Agency has set a maximum safe limit of 10mg/l nitrate-nitrogen for water used for human consumption.¹³ Those water bodies that exhibit characteristics that indicate that it is in an intermediate stage are classified as Mesotrophic.

There are three microbial processes important to nitrogen transformation as it relates to nonpoint source pollution from agricultural runoff. The first two are part of the mineralization process, which makes nitrogen available for plant use. Ammonia is the initial product of organic matter decomposition. When ammonia is oxidized, nitrites (NO_2^-) are formed which are readily converted to nitrates (NO_3^-). Nitrates are an important plant nutrient, however they are mobile in water and easily leach through the soil, readily moving below the root zone, particularly in sandy soils. It is also transportable as surface runoff, but usually in relatively small quantities. Ammonia itself is strongly adsorbed by the soil and is lost primarily with eroding sediment. The process of denitrification causes nitrogen to be lost to the atmosphere, working against the producer trying to maximize availability and retention. This benefits water quality by limiting the nitrogen available for leaching or for surface runoff, but may encourage producers to increase application. Some areas of the St. Louis River

¹³ Water Quality Field Guide 7.

basin, because of its geology, are susceptible to ground water contamination from nitrates; which create a serious pollution problem when occurring in sandy or shallow soils, or areas of fractured limestone.¹⁴

Phosphorus is the nutrient of concern in most Minnesota waters because it is the limiting nutrient for aquatic plant growth. It, like nitrogen, must be in the dissolved form to be readily used. Phosphorus content in most soils is low, ranging from between 0.01 and 0.2 percent by weight.¹⁵ Manure and fertilizers are used to increase available phosphorus for plant growth and root formation, hastening maturity, and stimulation of seed formation. Applied phosphorus reaches the water column primarily through runoff and erosion. Phosphorus is found in both dissolved form, and colloidal or particulate. It is largely particulate, inorganic phosphorus which is associated with eroding sediments. In many lakes, organic phosphorus comprises as much as 95 percent of the total phosphorus, and is largely tied up in living aquatic plant life.¹⁶ Dissolved inorganic phosphorus, orthophosphate phosphorus (H_2PO_4^-), is most likely the only form directly available to algae. Algae consume dissolved inorganic

¹⁴ Agriculture and Water Quality. Best Management Practices for Minnesota 6.

¹⁵ Water Quality Field Guide 33.

¹⁶ Water Quality Field Guide 8.

phosphorus and convert it to the organic form.

Inorganic phosphorus can either be dissolved in surface or subsurface waters, or attached to sediments. Although much of the sediment held portion acts as if it were permanently attached (highly adsorbed) to the soil particle, it can contribute as a source of the dissolved form. The portion of the phosphorus that is subject to change, that is, the available part of the sediment phosphorus, is referred to as the labile fraction. Although dissolved phosphorus is the plant available form, particulate phosphorus forms also contribute to the water quality problem due to the labile phosphorus. The equilibrium between the labile and dissolved inorganic phosphorus is dependent upon the chemical and biological characteristics of the water regime in the soil and the water body.¹⁷ Elemental phosphorus is seldom a toxicant, however it can become bioconcentrated in much the same way as mercury. A criterion of .10mg/l has been set by the U.S. Environmental Protection Agency for marine estuary waters.¹⁸

Sediment is the result of erosion. It is solid material, both organic and mineral, in suspension, being transported from its site of origin. It is the major

¹⁷ Water Quality Guide 8.

¹⁸ Water Quality Field Guide 7.

pollutant by volume in Minnesota surface waters.¹⁹ There are four basic types of erosion that produce sediment: splash erosion, sheet erosion, rill erosion, and gully erosion.²⁰ Splash erosion results from water droplets such as rain drops or irrigation water striking the soil surface and breaking the soil into fine particles that can be readily transported. Sheet erosion refers to water movement across the surface of the soil that removes thin sheets of soil. Rill erosion is the process by which water moves across the surface of the soil and cuts many small ravines a few inches across. When rills aggregate into small concentrated channels, the velocity is usually higher and additional instream sediment can be carried. Gully erosion takes place when water flows across a single site long enough to cut large gullies or ditches. Sediments from the different sources will vary in the amount of pollutant adsorbed to the soil particle. Sheet and rill erosion are most responsible for removing soil particles from the surface or plow layer of the soil. It is significant because the soil with the highest pollutant potential will be surface soils. Topsoil is richer in nutrient content, and will contain more chemical fertilizer and pesticides. In addition, topsoil is most active in

¹⁹ Agriculture And Water Quality. Best Management Practices For Minnesota 5.

²⁰ Charles D. Sopher and Jack V. Baird, Soils and Soil Management (Reston:Reston Publishing Co, 1982),250.

nutrient cycling and is highest in biological activity.

Detached sediment usually contains a higher percentage of finer and less dense particles than the soil from which it originates. Large particles are more readily detached from the soil because the particles are less cohesive. They will also settle out of suspension more quickly. Organic matter is not easily detached because of its cohesive properties, however, once detached, it is easily transported because of its low density. Clay particles and organic residues will remain suspended for longer periods of time and at slower flow rates. Small particles have a much greater adsorption capacity per mass than larger particles. As a result, eroding sediments generally contain higher concentrations of phosphorus, nitrogen, and pesticides than the original soil. Table 1 gives typical times for different soil materials of varying sizes to settle.²¹

Table 1

Material	Sediment Size	Time
Fine Sand	0.1mm	34 seconds
Silt	0.01mm	.94 hours
Clay	0.001mm	3.9 days
Colloids	0.0001mm	1.1 years

²¹ Leo Preston, "Water Quality And Pollution Identification" background paper, VI-2

Suspended soil particles can cause increased turbidity in the water body. The effects of excessive turbidity are decreased light penetration (which effects plant growth), increased water temperature through the absorption of solar radiation, and negative impacts on fisheries. The small mouth bass, which is a sight feeder, is an example of a fishery which is degraded by increased turbidity.²² Fisheries may also be affected by suspended solids covering spawning areas and clogging the gills of fish.

Animal waste is the most commonly perceived agricultural pollutant contributing to decreased water quality. Animal waste includes defecation of livestock and poultry, process water such as that from a milking parlor, and mixtures of feed, bedding, and soil. Animal wastes contribute nutrients as well as organic materials, and pathogens to the receiving water body. Manure, commonly used as a resource to add nutrients, organic matter, and even moisture to the soil is easily removed in runoff when applied to the soil surface. Autumn application of manure on a frozen field, as an example, will often result in high concentrations of nutrients being transported from the field during rainfall or snowmelt.

The problems previously addressed regarding nutrient loading in the water column also apply to animal wastes. If

²² Agriculture and Water Quality. Best Management Practices for Minnesota 4.

sufficient manure is applied to meet the nitrogen needs of a crop, phosphorus will be in excess. This in turn gives rise to the problems discussed concerning excess phosphorus. Generally, one pound of phosphorus which might likely come from manure can produce 500 pounds of aquatic plant growth, and concentrations as small as 30 parts per billion can cause nuisance levels of aquatic plants. ²³

The nutrient value in manure comes from its organic nature. Organic matter consists of carbon in combination with one or more elements. All substances of animal or vegetative origin contain carbon compounds. When manure or other natural organic matter is added to the water column, the decay process occurs just as it would on land, producing simpler compounds such as nitrates, ortho-phosphates, and gases such as nitrogen gas (N_2) and hydrogen sulfide (H_2S).

The organisms primarily responsible for the decomposition of organic matter are bacteria. If a large amount of organic matter/manure is added to a water body, the bacterial population will begin to grow, with the rate of growth expanding exponentially. The generation time, that is, the time it takes for each division, may vary from a few days to as little as twenty minutes. Because the bacteria demand oxygen, the available dissolved oxygen in the water column can be depleted quickly as the population explodes.

²³ Minnesota Pollution Control Agency, Running your feedlot (St. Paul: Minnesota Pollution Control Agency, 1988,1991) 2.

With sufficient organic matter added, and the subsequent action of bacteria, the dissolved oxygen level can approach zero. The area where oxygen depletion is most significant may be far from the point where the organic matter enters the water column. The level of depletion will also depend on the water volume, turbulence, and velocity of the water body. Although turbulence will generally keep sediment suspended for a longer period of time, and can itself cause water quality problems, increased turbulence can have a positive effect in that it brings air into the water helping to replenish the dissolved oxygen. Thus a turbulent, fast moving water body can assimilate more organic waste than a slower more placid water body.

An adequate supply of dissolved oxygen is essential for a good fishery and long term health of a water body. Warm water fish species can survive for much longer periods of time with relatively low dissolved oxygen levels (1 to 5 ppm) than cold water species.²⁴ Most cold water species require dissolved oxygen levels well above 5 mg/l for successful growth and reproduction.²⁵

The ability of an organic pollutant such as manure to deplete the oxygen level in a water body is often measured in terms of its biochemical oxygen demand, or BOD. The BOD test

²⁴ Water Quality And Pollution Identification VIII-4

²⁵ Water Quality And Pollution Identification VIII-4

measures the amount of oxygen required by bacteria to consume organic matter over a five day period. Table 2 compares the BOD₅ values for agricultural waste and treated and untreated municipal waste water.²⁶

Table 2

Source	BOD ₅ (mg/l)
Milking Center Waste	1,500
Influent to a lagoon from:	
Dairy Cattle	6,000
Beef Cattle	6,700
Swine	12,800
Poultry	9,800
Effluent from a lagoon for:	
Dairy Cattle	2,100
Beef Cattle	2,345
Swine	4,480
Poultry	3,430
Raw domestic sewage	200
Treated sewage from a secondary treatment facility	20

BOD₅ values for the untreated and treated municipal waste water are lower due to greater water content than that found with agricultural waste. In total volume, an average dairy operation of 40 cows and their youngstock generates a

²⁶ Water Quality And Pollution Identification VIII-5.

waste load equal to that produced by 750 people.²⁷ Many poultry operations produce waste loads equal to cities with populations over 10,000.²⁸ Table 2 clearly demonstrates that while the total volume of organic livestock waste may be smaller in volume relative to municipal waste water discharges, it is much more concentrated, and is capable of causing severe damage to a water body.

Pesticides, which include insecticides, herbicides, and fungicides, are used extensively in production agriculture to control pests. The use of these chemicals increases yield, however they also pose a potential threat to water quality. A study by the Minnesota Department of Health and the Minnesota Department of Agriculture found that of 500 wells sampled throughout the state, 39 percent were found to have traces of pesticides in them.²⁹ Although the sampling took place in geologically sensitive areas, and was not intended to be representative of all aquifers, this study does point to an alarming amount of pesticides pollution from leaching and possibly runoff.

²⁷ Minnesota, Pollution Control Agency, Protecting Minnesota's Waters... The Land-Use Connection (St Paul: Minnesota Pollution Control Agency, 1986) 27.

²⁸ Protecting Minnesota's Waters... The Land-Use Connection 27.

²⁹ Agriculture And Water Quality. Best Management Practices For Minnesota 6.

Pesticides are lost from agricultural land through four primary processes. These are volatilization, degradation (both chemical and biological), adsorption, and solubility. Volatilization does not appear to be a serious threat to water quality, therefore only the latter three will be discussed. Degradation is the time it takes a pesticide to breakdown to other forms. A pesticide which does not breakdown quickly can be a serious hazard as it moves into a water body. In addition, the breakdown products can also present a toxic hazard. The pesticides or their breakdown products can accumulate in the water body, negatively effecting the entire food chain. Sublethal effects include the behavioral and structural changes of organisms in the water body that in some way jeopardizes their chances for survival. Factors that determine pesticide degradation rates and persistence include soil type, soil-water content, pH, temperature, clay content, and organic matter content. Increasing soil pH will generally increase the degradation rate. The most dynamic and unpredictable factors in degradation are the soil microbial population and the environmental variables that control microbial activity. Increased microbial activity and decreased pesticide adsorption associated with higher temperatures generally enhance pesticide degradation. Pesticide degradation below the root zone is often limited because of the absence of organic matter. The persistence of a pesticide in a soil

system is measured in the time it takes for one-half of the applied material to disappear (half-life). The time required for 75 percent to disappear would be two half lives and so on.

Adsorption is the ability of a pesticide to bond with the soil. Some pesticides stick very tightly to soil particles while others are more easily partitioned. Adsorption is measured by the partition coefficient. The larger the partition coefficient, the greater the quantity of pesticide adsorbed to the soil. The extent to which a pesticide is adsorbed by soils (or sediment) is determined by several physical and chemical properties of both the soil and the pesticide. Regression analysis of the partition coefficient with several soil physical and chemical properties suggests that soil organic matter or organic carbon may be the single best indicator of pesticide adsorption coefficients for many pesticides.³⁰ It also appears that the partition coefficient when adjusted to reflect organic carbon content of the soil or sediment is essentially independent of soil type.

Solubility is the ability of a pesticide to dissolve in water. The greater the solubility, the greater the potential for a pesticide to leach through the soil, or to be lost in runoff water. In general, the greater the water solubility

³⁰ Water Quality Field Guide 11.

of a pesticide, the lower the value of the partition coefficient. The amount of field-applied pesticide that leaves a field in the runoff and enters a water body is primarily a function of the intensity and duration of a rainfall, and the length of time between pesticide application and rainfall occurrence. Analysis indicates that greater than 90 percent of the pesticide is lost in the water phase of surface runoff, except for highly adsorbed pesticides and for large sediment loads. Pesticide concentrations in the sediment phase are generally much higher than those in the water phase because of the larger volume of water in the runoff event compared to the sediment mass. The total pesticide loss, however, is greater in the water phase of surface runoff.³¹

While there is a potential for pesticides to become a serious pollution problem, it is not realistic to conclude either that pesticides are not going to be used, or that they should not be used. It is imperative, however, that agricultural producers and water quality managers know the properties and characteristics of the pesticides that are used. It is also imperative that this information be used as part of an effective water quality plan.

³¹ Water Quality Field Guide 13.

IV: Best Management Practices:

The problems associated with nutrients, sediments, animal wastes, and pesticides are not without solution. A system of practices can reduce nonpoint source pollution from agricultural related runoff. Once a water quality problem has been identified, and the pollutants contributing to decreased water quality have also been identified, best management practices can be applied to achieve a water quality goal.

Selecting a best management practice will depend on the pollutant's availability, detachment, and means of transportation into the water column. The following considerations should be evaluated in deciding which practices are necessary to correct a water quality problem: (1) ability of the practice to achieve a specified water quality goal, (2) economic feasibility of the practice, (3) effect of the practice on ground water and/or surface water, (4) suitability of the practice for a particular site.³² In assessing the economic feasibility of best management practices, several additional factors must be considered: (1) the probable cost of the practice, (2) the limitations of the soil, (3) any effect on yields, (4) the effect on production and labor costs, (5) the market for the crops to be grown,

³² Agriculture and Water Quality. Best Management Practices for Minnesota 12.

either in the market place, or through livestock.³³ With regard to suitability, a best management practice that is not well suited to a particular site will not have support from the producer, and will likely mean being discontinued. Factors such as the terrain, the equipment that the producer has, and possible effect on field conditions as well as past success under similar conditions will be important in the decision making process.

The relative potential of a nutrient as a pollutant depends on its availability for loss, which involves not only the amount of the nutrient present, but also its position in the soil. The agricultural producer can decrease nutrient availability by managing rates of nutrient application, monitoring the levels of nutrient buildup in the soil, particularly phosphorus, and by incorporation of the nutrients into the soil. Also important is the timing of nutrient application and the type of nutrient used. The rate at which a nutrient is applied is significant in controlling nutrient pollution. While a proper balance of nutrients is in many cases essential to healthy plant growth, over application can be damaging to a crop, and dramatically increase the potential for excess nutrients to enter the water column. Some of the factors that should be considered in rates of application are the yield goal for a specific

³³ Agriculture and Water Quality. Best Management Practices for Minnesota 13.

100 lbs/acre.³⁴ If left in the rotation for two or more years, significant amounts of nitrogen can be available in the soil. Nitrogen loss from corn can be as great as 10 times that of sod pasture. The use, therefore, of sod pasture rotations can significantly reduce losses of solid phase and dissolved forms of nitrogen and phosphorus. Cover crops or green manure crops such as small grains, sorghum, millet, and legumes protect the soil during the period when it is normally bare, or has little crop residue cover. If there is a vegetative cover when an erosion event occurs, either rain, snow melt, or wind, the amount of erosion will be greatly decreased and nutrients that would otherwise be lost are kept in the field and used by the crop.

Conservation tillage is another inexpensive yet effective way to prevent nutrient loss and soil loss by erosion. Conservation tillage is defined by the Soil Conservation Service as any tillage method which leaves at least 30 percent of the soil surface covered with crop residue after planting. The soil is tilled only to the extent required to prepare an adequate seedbed, incorporate chemicals, control weed growth, and plant the crop. Conservation tillage can be an entire field surface, or may involve only strips where a crop is planted. The aim of strip tillage is to provide a favorable seedbed, while

³⁴ Water Quality Field Guide 34.

leaving the untilled row middles as a hostile environment for weed growth, and as a means to reduce erosion from surface runoff. The width of the strip can vary from 2 to 12 inches with typical reduction in soil loss ranging from 40 to 95 percent.³⁵ For full width conservation tillage, soil loss is reduced between 40 and 90 percent, and with wide strip or "ridge" tillage, soil loss is reduced up to 60 percent.³⁶ Conservation tillage is effective in controlling soil erosion and also reduces the amount of nutrient and pesticide pollution entering the water column by trapping pollutants that are attached or adsorbed to the soil particle. It is important however to emphasize that reductions in soluble or adsorbed nutrient and pesticide pollution will also be highly dependent on the nutrient and pesticide management practices that are used in conjunction with conservation tillage.

Proper pesticide use must be based on practices that manage pesticide use in a manner that makes efficient use of the chemicals and prevents contamination of a water body. This is accomplished by mixing pesticides, and calibrating equipment accurately, following careful handling procedures, and by properly disposing of wastes.

Improper pesticide waste disposal can cause potentially

³⁵ Agriculture And Water Quality. Best Management Practices For Minnesota 30.

³⁶ Agriculture And Water Quality. Best Management Practices For Minnesota 30.

serious surface and ground water contamination, as well as dangerous health hazards. The wastes of most concern are empty containers, excess pesticide, and materials containing pesticide residue. All empty plastic containers are required to be triple rinsed before they are discarded, and the rinse water added to the application solution. The greatest potential hazard comes from spills. Agricultural chemicals that are spilled can readily enter surface water, or leach into ground water. Even a small leak can create a significant concentration of chemical in a very small area. If a leak does occur, it must be treated quickly and properly. Diluting the pesticide does not solve a hazardous waste problem. Diluting 10 gallons of hazardous waste with 90 gallons of water makes 100 gallons of hazardous waste.

Other methods that have proven to be successful in reducing sediment loss, nutrient loss, and potential pesticide runoff are contour farming, strip cropping, use of a filter strip, and field borders. Contour farming simply refers to rows that run around the slope rather than up and down the slope. This method reduces erosion, and therefore nutrient loss and potential pesticide runoff, and increases infiltration. There is also an economic advantage to contour farming in lower fuel costs for the producer. The rate of reduction in erosion ranges from 40 to 50 percent on slopes

of between 2 and 7 percent.³⁷ If contour farming is combined with conservation tillage for these same slope values, erosion can be reduced by as much as 70 to 80 percent.³⁸ Because contour farming does increase infiltration, the potential for leaching agricultural chemicals is increased. Therefore contour farming should be used in conjunction with an effective pesticide management plan. Contour farming is most suitable on land that has a relatively uniform slope. There is little value in contour farming in fields that have varying slopes that break in different directions. Where odd areas are formed because of contour farming, correction strips of close growing vegetation can be used to eliminate point rows.

Strip cropping is a system of planting crops in systematic strips. This is particularly effective in controlling wind and water erosion. The crops are planted such that a strip of sod or close growing crop is alternated with a strip of row crops. Contour strip cropping on land with a slope of 2 to 7 percent can reduce erosion by as much as 75 percent.³⁹ When strip cropping is used with contour farming, grassed waterways, terraces, or some other diversion

³⁷ Water Quality Field Guide 38.

³⁸ Water Quality Field Guide 38.

³⁹ Water Quality Field Guide 38.

should be used in order to direct runoff. When strip cropping is used to protect cropland from wind erosion, the strips should be laid out as nearly as possible at right angles to the prevailing winds. Width of strips will be dependant upon the type of vegetation used.

Filter strips are strips of grass or other close growing vegetation intended to remove sediment as well as prevent nutrient loss and reduce pesticide loss into a water body. Filter strips can be used on cropland that is adjacent to streams, rivers, and lakes, or cropland at the lower end of a field as part of a waste management system that reduces nutrient, sediment, and chemical runoff. They are most effective with sheet flow erosion. The vegetation slows the nearly uniform water flow over a field surface, and traps the solid material. Sediment reduction from between 30 and 50 percent can be expected with a well planned filter strip.⁴⁰ Filter strips are not effective in trapping either dissolved nutrients or pesticides, nor do they significantly reduce fine grained suspended sediment. It has also proven effective in construction and silviculture sites in reducing sediment delivered to receiving waters. A filter strip must be designed wide enough to trap eroded sediment as it passes over the strip. While filter strips are most effective in controlling sheet erosion, they can be used with limited

⁴⁰ Agriculture And Water Quality. Best Management Practices For Minnesota 34.

success to control more concentrated flows. An important factor in the construction of a filter strip is the outlet or sediment basin of the strip, which must be stable and planned so as not to cause further erosion problems.

Field borders are areas of permanent vegetation established on the edge of a field. Field borders are effective in reducing runoff from end rows, particularly when contour farming is used and end rows run up and down a field. A field border, like filter strips, provides some filtration of sheet erosion, reducing sediment and nutrients or agricultural chemicals from entering the water column. Like filter strips, consideration must also be given to the planning of sediment basins for the same reasons stated for filter strips.

Manure is a valuable resource as well as a necessary by-product of livestock production. If manure application and livestock holding areas are properly managed, few pollutants will be discharged into the water column. The most effective controls in managing animal waste from field application are those that limit availability. Availability is reduced by limiting application rates to what is necessary for adding nutrients and organic matter to the soil, timing the application so that it does not coincide with periods of high runoff, by incorporating the manure whenever possible, and by carefully choosing the application site. In assessing nutrient level, nitrogen and phosphorus content must be

determined. This can be done through soil testing or by contacting the local Soil Conservation Service representative. Guidance is also available regarding rates of application in the Soil Conservation Service Agricultural Waste Management Field Manual. Application should be set back from surface waters with setback distances that vary with the field topography, soil type, and time of application. Distances to surface waters may be reduced if runoff is restricted by filter strips, field borders, or natural topography. Table 3 gives separation distances from surface waters for surface application.⁴¹

Table 3

Slope	Soil Texture	Time of Year	Minimum Separation (feet)
0-6%	Coarse	May-October	100
0-6%	Course	November-April	200
0-6%	Medium to Fine	May-October	200
0-6%	Medium to Fine	November-April	300
Over 6%	Course	May-October	200
Over 6%	Medium to Fine	May-October	300
Over 6%	All Soils	November-April	Not Recommended

Agricultural waste management systems are used to store manure and other agricultural waste such as milk parlor wash until it can be applied to cropland. Waste storage facilities differ depending on the type of agricultural operation. Waste storage ponds are earthen structures which

⁴¹ Running your feedlot 10.

provide temporary storage. Other waste storage structures include specifically built pits or above ground structures of a more permanent nature. Whether an earthen structure or more permanent structure is appropriate will be dependant upon soil type, and the height of the water table.

Animal waste management can be extremely effective in reducing the amount of pollutant that reaches a water body. A properly designed system used correctly can reduce the amount of nutrient runoff, bacterial input, suspended solids, and organic material that would deplete oxygen supplies as part of the decomposition process, or introduce pathogens into a water body. Pollution reduction as a result of animal waste management systems has been as much as 50 to 75 percent state-wide, although 100 percent can be achieved from systems that totally control runoff.⁴²

Animal access to surface water must also be restricted. Cattle in streams increases turbidity, increases sediment loading, and also increases bacterial and nutrient input. Livestock exclusion can result in a 50 to 90 percent reduction of suspended solids and total phosphorus originating in a stream reach.⁴³ Providing adequate shade and

⁴² Agriculture And Water Quality. Best Management Practices For Minnesota 40.

⁴³ Agriculture And Water Quality. Best Management Practices For Minnesota 48.

the proper use of livestock insecticides can eliminate the need for livestock to congregate in streams and tributaries for relief from heat or insects. It may also be necessary to develop alternative sources of drinking water, and restrict access by fencing.

V: Addressing the problem - Remedial Action Plans:

Incorporation of best management practices will be most effective if a vehicle exists for problem identification and solution planning. Ideally this vehicle would include the cooperation of all interested parties, such as producers, water quality specialists, other resource users that might impact on water quality and water use, and agricultural production specialists from the state such as Department of Agriculture and Extension personnel. A mechanism for moving forward on water quality issues does exist in the Remedial Action Plans outlined in the Great Lakes Water Quality Agreement of 1978 (as amended by Protocol, November 18, 1987).⁴⁴

The Remedial Action Plan process is part of a long history of water quality agreements between the United States and Canada. In 1909 the Boundary Waters Treaty was signed between the United States and Great Britain. The Boundary Waters Treaty established the International Joint Commission, a bi-national organization entrusted with the responsibilities of regulation of Great Lakes water levels, to carry out studies as the parties might request, and act as

⁴⁴ International Joint Commission United States and Canada. "Revised Great Lakes Water Quality Agreement of 1978 as amended by Protocol". November 18, 1987, Annex 2.

arbitrator for international water resource disputes.⁴⁵ One of the first tasks of the International Joint Commission (IJC) was to study water quality problems in the Great Lakes resulting from the discharge of raw sewage. The IJC issued a report in 1919 that recommended the issue be addressed in a comprehensive treaty to counter water quality problems, and to protect water quality in the Great Lakes. The report however was largely ignored and no action was taken.

Decades of neglect and degradation of Great Lakes water quality ensued, reaching somewhat of a climax in 1972, when mounting scientific research and public opinion compelled the governments of the United States and Canada to enact The 1972 Great Lakes Water Quality Agreement. This Agreement required specific steps to reduce discharge of conventional pollutants, namely phosphorus, and more generally acknowledged a need to look at the serious water quality problems that existed throughout the Great Lakes ecosystem. Continued monitoring and research following the 1972 Agreement showed that while improvements in conventional pollutants as a result of efforts to create or upgrade waste water treatment facilities had improved water quality with respect to those pollutants, a serious problem still existed in chemical toxins. The Agreement was revised in 1978, retaining all the essential components of the 1972 Agreement,

⁴⁵ "Revised Great Lakes Water Quality Agreement of 1978 as amended by Protocol", Article VII.

and added new emphasis on "...maintaining the chemical, physical, and biological integrity of the water of the Great Lakes Basin Ecosystem", and the elimination or reduction "...to the maximum extent practical the discharge of pollutants into the Great Lakes System". With regard to agriculture, the 1978 Agreement addressed related water quality impairment in Article VI 1 (e), outlining "Measures for the abatement and control of pollution from agriculture, forestry, and other land use activities". These measures include:

(i) Measures for the control of pest control products used in the Great Lakes Basin to ensure that pest control products likely to have long term deleterious effects on the quality of water to its biota be used only as authorized by the responsible regulatory agencies; that inventories of pest control products used in the Great Lakes Basin be established and maintained by appropriate agencies; and that research and educational programs be strengthened to facilitate integration of cultural, biological, and chemical pest control techniques;

(ii) Measures for the abatement and control of pollution from animal husbandry operations, including encouragement to appropriate agencies to adopt policies and regulations regarding utilization of animal wastes, and site selection and disposal of liquid and solid wastes, and to strengthen educational and technical assistance programs to enable farmers to establish waste utilization, handling, and disposal systems;

(iii) Measures governing the hauling and disposal of liquid and solid waste, including encouragement to appropriate regulatory agencies to ensure proper location, design and regulation governing land disposal, and to ensure sufficient, adequately trained technical and administrative capability to review plans and to supervise and monitor systems for application of wastes

on land.⁴⁶

Additional items of concern addressed were the need for measures to control soil loss, and the need for measures to both encourage and facilitate improvements in land use planning and management programs to account for impacts on Great Lakes water quality. Also suggested were advisory programs and measures to abate and control inputs of nutrients, toxic substances and sediments from agriculture, and the conduct of further non-point source programs in accordance with Annex 13 of the 1978 Agreement as amended.⁴⁷

Following the 1978 Agreement, the IJC identified 43 areas in the Great Lakes Basin as having impaired beneficial uses of the water resource due to pollution. The 1978 amendments did not, however, outline a means of implementation. Therefore in 1987, the Agreement was again modified to include Remedial Action Plans as a means to implement provisions of the Agreement, and to address those geographic areas in the Great Lakes basin most severely impacted.⁴⁸ Remedial Action Plans were directed to be

⁴⁶ "Revised Great Lakes Water Quality Agreement of 1978 as amended by Protocol", Article VI(1)(e)(i)-(iii).

⁴⁷ "Revised Great Lakes Water Quality Agreement of 1978 as amended by ,Protocol", Annex 13(1).

⁴⁸ "Revised Great Lakes Water Quality Agreement of 1978 as amended by Protocol", Annex 2.

developed for each of the 43 Areas of Concern (AOC) identified, incorporating a comprehensive ecosystem approach, and encouraging citizen participation. The purpose of such plans is:

...(to) provide a continuing historical record of the assessment of Areas of Concern or Critical Pollutants, proposed remedial actions and their method of implementation, as well as changes in environmental conditions that result from such actions, including significant milestones in restoring beneficial uses to Areas of Concern or open lake waters. They are to serve as an important step toward restoring and maintaining the chemical, physical and biological integrity of the Great Lakes Basin Ecosystem.⁴⁹

Remedial Action Plans are to be developed jointly emphasizing cooperation between Canadian Provincial Governments and the State Governments and will include definitions and detailed descriptions of the environmental problem in the Area of Concern. It will also contain a definition of the causes of known impairment, evaluation of remedial measures in place, additional alternative measures to restore beneficial uses, and selection of measures for restoring beneficial uses as well as a schedule for implementation. In addition to these activities, the Plan is to identify responsible agencies for implementation, and a process for evaluating implementation and effectiveness as well as a description of the monitoring methods used to track implementation and effectiveness.

⁴⁹ International Joint Commission United States and Canada. "Revised Great Lakes Water Quality Agreement of 1978 as amended by Protocol". November 18, 1987, Annex 2(2)(b)

Remedial Action Plan development proceeds in three stages: (1) problem identification, (2) action planning, and (3) implementation. Stage I, problem identification, identifies and describes the problem in the Area of Concern. Included is a review of the International Joint Commission's "impaired beneficial use" criteria for designating areas of concern. Stage II, the action plan, will proceed with the completion of transitional activities that were begun in Stage I, the development of action items to solve the problems identified as a part of Stage I, and a range of alternative actions will be proposed consistent with the Remedial Action Plan goals and objectives. Stage III, implementation, will actually execute actions recommended in Stage II. Rates of accomplishment will be dependant upon complexity of the problems identified. Stage III will also include monitoring to determine effectiveness of the actions taken, and to ensure that remedial actions restore impaired uses.

The 1978 Agreement was codified into Federal Law by enactment of the Great Lakes Critical Programs Act of 1990.⁵⁰ This added Federal "teeth" to the Remedial Action Plan process. The Act amended the Clean Water Act to embody the goals of the 1978 Agreement and, among other things, to

⁵⁰ Great Lakes Critical Programs Act Of 1990. 33 U.S.C. § 1268 - 1329.

improve accountability for implementation of the agreement.⁵¹

It also established the Great Lakes National Program Office within the Environmental Protection Agency which is tasked with cooperating with other Federal agencies, State, tribal, and international agencies in developing and implementing plans and actions to carry out responsibilities under the 1978 Agreement as amended by the 1987 Protocol.⁵² With regard to Remedial Action Plans, the Great Lakes Critical Program Act of 1990 mandates submission to the Program Office, submission to the International Joint Commission, and inclusion into state water quality plans.

The St. Louis River was originally designated an Area of Concern by the IJC due to large loads of suspended solids, nutrients, and high levels of biochemical oxygen demand resulting from direct discharge into the river by various industries and communities. These pollutants had a severe impact on beneficial uses and created stress conditions for local fish populations. The IJC requested that the Minnesota Pollution Control Agency and Wisconsin Department of Natural Resources develop a Remedial Action Plan which would identify strategies to control sources of pollution, abate environmental contamination already present, and restore

⁵¹ Federal Water Pollution Control Act 33 U.S.C. § 1268.

⁵² Federal Water Pollution Control Act. 33 U.S.C. § 1268(a)(3)(b) and § 1268(a)(3)(c)(1)

beneficial uses in the St. Louis River Area of Concern. Impairment of beneficial uses, as defined by the Water Quality Agreement, is a change in the chemical, physical, or biological integrity of the Great Lakes system. The St. Louis River basin Remedial Action Plan addresses the following concerns: (1) the environmental problems, including geographical extent of the area affected and research needs, (2) beneficial uses that are impaired, (3) the causes of the problems and sources of pollutants, (4) remedial measures proposed to resolve the problems and restore beneficial uses, (5) a schedule for implementing and completing remedial measures, (6) agencies and jurisdictions responsible for implementing and regulating remedial measures, (7) the process for evaluating remedial program implementation and effectiveness, (8) surveillance and monitoring activities that will be used to track effectiveness of the programs and eventually confirm that the AOC beneficial uses have been restored.⁵³

An initial Remedial Action Plan draft was completed in 1985 (prior to the 1987 Protocol), and was submitted to the U.S. Environmental Protection Agency (EPA) by the Minnesota Pollution Control Agency (MPCA).⁵⁴ The Environmental Protection Agency's response was to suggest a more

⁵³ Remedial Action Plan I-5.

⁵⁴ Remedial Action Plan II-1

comprehensive plan to address the problems associated with the St. Louis River basin, and to develop necessary solutions and actions.⁵⁵ To this end, EPA hired Science Applications International Corporation (SAIC) to put the available information and data into a suitable format. Minnesota and Wisconsin reviewed the SAIC document and concluded significant change, revision, and expansion of the Plan was necessary. It was at this juncture that it became evident that there was a need beyond simple IJC and Federal mandate for public input and involvement. To address public concerns, a 32 member Citizens Advisory Committee (CAC) was formed in June, 1989 to oversee the Plan development. The committee was tasked with identifying issues to be considered, set goals for remedial action activities, and act in an advisory position to the MPCA and the Wisconsin Department of Natural Resources (WDNR).

The CAC formed two subcommittees, a Steering Committee, and a Public Relations/Information and Education Committee. The Steering Committee functioned to guide the CAC by organizing, developing, and recommending activities or options that the CAC would then pursue. The Public Relation/Information and Education Committee, active in 1990, organized public meetings to report on the Plan's progress. In 1989, five Technical Advisory Committees (TAC's) were

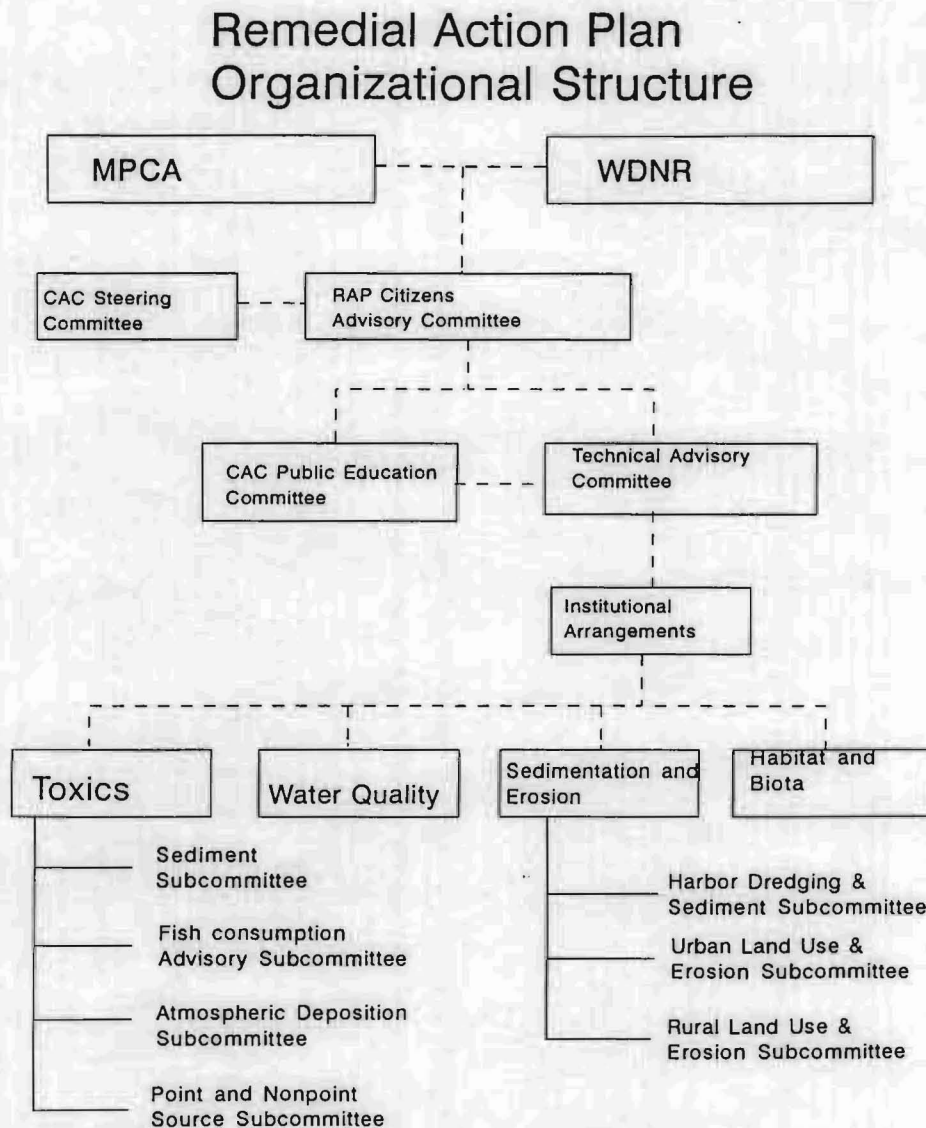
⁵⁵ Remedial Action Plan II-1

formed to provide scientific and technical advice to the CAC. The TACs helped to analyze the complex water quality issues, and recommend a range of solutions. The five TACs established were Toxics, Water Quality, Sedimentation and Erosion, Habitat and Biota, and Institutional Arrangements. Toxics, Water Quality, Sedimentation and Erosion, and Habitat and Biota carry out functions in support of the CAC in identifying impaired beneficial uses and their causes, proposing goals and objectives to restore uses when degraded, and recommending solutions. The Institutional Arrangements TAC was assigned to work on how recommendations can be implemented giving consideration to economic, political, social, and policy factors. Institutional Arrangements also evaluates the advantages and disadvantages of the recommended actions, and identifies responsible parties required for implementation. Following the Institutional Arrangements TAC evaluation, recommendations are sent to the CAC which then produces final recommendations. Overseeing the entire process is the Remedial Action Plan coordinators from the MPCA and the WDNR. They, in turn, report back to the EPA. Figure 4 is an organizational chart of the St. Louis River system Remedial Action Plan organization.

Despite much detailed work by the CAC and involved agencies, several deficiencies in the St. Louis River Plan regarding the role of nonpoint source pollution exist, particularly nonpoint source from agriculture. Although

there has been substantial reduction in point source

Figure 4



Source: Minnesota Pollution Control Agency; Wisconsin Department of Natural Resources, The St. Louis River System Remedial Action Plan Stage I, Minnesota Pollution Control Agency; Wisconsin Department of Natural Resources, 1992

phosphorus loadings, the Remedial Action Plan stage I report completed April, 1992, concedes that phosphorus concentration in the estuary remains at levels that indicate a eutrophic condition might be expected. Algal blooms are lower, however, than would be expected given phosphorus concentrations. The Remedial Action Plan explains that several investigators have proposed that the limiting factor in algal growth in the estuary is poor light penetration caused by turbidity and color. The Plan states that in sampling conducted at 18 sites from Allouez Bay to Fond du Lac in 1984-1987, nutrients in the estuary were not fully expressed as phytoplankton biomass, perhaps due to high turbidity. Paleolimnological examinations of core samples indicate that the rate of sedimentation in the estuary has been increasing since 1900.

The rates of sedimentation, documented turbidity, and high phosphorus loading (despite the lack of algal blooms) all seem to suggest significant non-point source pollution problems. The Plan does draw a possible connection between phosphorus availability and transport through the system and the high sediment loading. The Plan references a 1972 National Eutrophication Survey that developed a nutrient budget for St. Louis Bay which estimated that 50 percent of the phosphorous inputs into the Bay were from non-point sources. In 1982, a study of nutrient loadings to the Bay

found that while point source loadings had decreased to one fifth of the previous input, non-point source inputs accounted for 90 percent of the nutrient loadings, and that overall loadings were similar between 1972 and 1982.⁵⁶ It is important to note that these studies did not include point source loadings from Wisconsin, and did not take into account the Lake Superior seiche. Despite the evidence of strong correlation between phosphorus loading and sedimentation, the possibility of a eutrophic condition, and data collected on the rates of sedimentation, little or no quantitative information on non-point source pollution exists for the St. Louis River AOC. The Remedial Action Plan plainly states this, while also conceding that although eutrophic conditions have not been noted within the St. Louis estuary in the last decade, nutrient loading from the system into Lake Superior is of concern.

An examination of possible causes of non-point source pollution contributing to the water quality degradation of the St. Louis River and Lake Superior indicate that agriculture is a significant factor. While the northeastern portion of Minnesota and Wisconsin are not as agriculturally intensive as other portions of the State, a significant amount of acreage is devoted to agriculture. Total cropland acreage in the St. Louis River basin in the three primary

⁵⁶ Remedial Action Plan V-32.

counties (Carlton, St. Louis, and Douglas County Wisconsin) totals 187,206 acres.⁵⁷ The Remedial Action Plan states that the main source of nutrients from agricultural operations is animal waste runoff from livestock and poultry operations, and fertilizer runoff, however no study to substantiate this is cited.

The lack of information on non-point source pollution from animal waste runoff is a problem which could be immediately addressed. Considerable attention has been given to nutrient loading reduction as a result of improvements in waste water treatment and the construction and consolidation associated with the Western Lake Superior Sanitary District treatment plant and upgrades to the Superior Waste Water Treatment Plant. A review of BOD₅ values from Table 4, however, again indicates that organic livestock waste, while consisting of less volume, is much more concentrated than municipal waste water discharges. With this in mind, given the high nutrient loading in the St. Louis River basin, it would seem that the need to address the problem of animal waste runoff is great.

A beginning point might be to identify herd and flock sizes of dairy and poultry operations in the three county area. Once dairy herd sizes have been established, dairy herd records can be used to accurately estimate the weight of

⁵⁷ Remedial Action Plan V-36.

each dairy cow. This information, along with the size and type of poultry flocks in the region can then be used to estimate total manure production and the resultant nutrient content. Although this information will not indicate the quantity actually reaching the water body, it will give an estimation of the amount of nutrient from animal waste which is available. Further measurement of dissolved oxygen levels and water samples can then provide an indication of how much nutrient is in the water column and a correlation can be drawn. In addition, information on compliance with rules on controlling feedlot pollution based on State law (Minnesota Rules, Chapter 7020) needs to be examined for actual compliance. Quantitative data also should be collected to determine the amount of manure that is applied to cropland, and the timing of manure applications. This, in conjunction with erosion data, will aid in determining if manure application is contributing significantly to the water quality problems already being caused by animal waste runoff from feedlots. The information gathered can then be used in determining best management practices for manure application and storage, and controlling sediment transport from erosion that may be carrying nutrients from field applied manure into the water column.

The same process should be employed for application of commercial fertilizers. Data on types of erosion and transport into the water column should be collected, and

fertilizer content (percent nitrogen, phosphorus, and potash) analyzed. Information on types of fertilizer used can easily be solicited from agricultural producers either by the county extension agent, or Soil Conservation Service representative. Given application rates, timing, and method of application (i.e. top dress, side dress, incorporation, or broadcast), combined with data on sediment transport, adsorption of fertilizer to the soil particle, and knowledge of the types of erosion most prevalent, accurate estimates can be made regarding the role of commercial fertilizer in nutrient loading.

Turbidity in the St. Louis River indicates that an erosion problem exists. Continued sedimentation in the St. Louis River and in particular Superior Bay and the harbor area suggests that much of the turbidity is from new erosion rather than sediment staying in suspension for long periods of time. The erosion and subsequent turbidity presents a problem not only from a transport of nutrients standpoint, but also its effect on water quality and the negative impact on fisheries. Sediment volumes and statistics on the amount of annual dredged material suggest that fishery quality is impacted, and that suspended solids may well be in the range of 80-400 mg/l or ppm. Although much of the focus on fisheries in the St. Louis River basin has been in regard to toxins and dissolved oxygen levels, the turbidity caused by erosion and suspended material and its effect on fisheries

should not be overlooked. While not all of the sedimentation is caused by agriculture, there does not seem to be any data indicating the estimated impact of erosion, or types of erosion caused by agriculture located in the Area of Concern. A lack of data makes it difficult to implement best management techniques. Even if the type of best management technique(s) could be identified, questions regarding the width of filter strips or field borders for example cannot be answered. Although not as significant, the impact of sediment already in suspension should also be examined. While sandy soil particles stay in suspension as little as 34 seconds, clay and organic colloids common to the region remain in suspension much longer; 3.9 days and 1.1 years respectively (Table 1). Once field evaluation has determined the type of erosion, a solution incorporating previously discussed best management practices can be implemented.

In addition to animal waste, fertilizer problems, and sedimentation, the Remedial Action Plan also identifies pesticide runoff as a result of surface runoff and/or seepage to ground water as a potential nonpoint source pollution problem resulting from agricultural activities. Table 4 lists some of the most common pesticides and insecticides in the St. Louis River Area of Concern.⁵⁸

⁵⁸ Remedial Action Plan V-36.

Table 4

Pesticide	Trade Name
Atrazine	AAtrex, Atratol
Cyanazine	Bladex
EPTC	Eptam, Eradicane
Glyphosate	Accord, Roundup, Lorox, Ranger
2,4-D Sol Amine	Weeder
Insecticide	Trade Name
Aldicarb	Temik
Diazinon	DZN, Knox-Out
Malathion	Cynthion

The Remedial Action Plan lists the total acreage to which agricultural chemicals were applied for Carlton, Douglas, and St. Louis Counties. These are listed in Table 5.⁵⁹

Table 5

Chemical Use	Carlton County Mn	Douglas County Wi	St. Louis County Mn
Fertilizers	9,603	4,994	14,738
Insect, nematode, disease and weed control	4,531	1,800	6,393
Defoliation and crop control	104	-	90

Beyond identifying these most common pesticides and

⁵⁹ Remedial Action Plan V-37.

insecticides, the Remedial Action Plan fails to address potential problems that these chemicals can cause in the water column. Of the pesticides, Atrazine, Cyanazine, EPTC and 2,4-D-Sol Amine all have either medium or high surface loss potential, and medium or high leaching potential. Glyphosate has a high surface runoff potential, but a low leaching potential. 2,4-D Sol Amine has an extremely high solubility factor. Glyphosate has an extremely high partition coefficient value indicating it is strongly adsorbed to the soil particle contributing to a high surface runoff loss potential. Atrazine has a half-life in the soil of approximately 60 days making it extremely susceptible to runoff following rainfall or other erosion events that would carry it into the water column. EPTC and Glyphosate also have relatively long half-lives, each measuring approximately 30 days. With respect to the insecticides, Aldicarb, while having a low surface runoff loss potential, has a high potential for leaching, as does Diazinon. Diazinon has medium potential for loss to surface runoff. Malathion has both a low potential for loss to surface runoff and a low potential for leaching. While information on pesticides is readily available, there has been no attempt to address potential loss to the water column, detachment or transport as a result of surface runoff, leaching, or the effects on water quality.

Indeed all of the potential sources of nonpoint source

pollution from agricultural runoff need to be examined as possible contributors to the water quality problems in the St. Louis River basin. In many instances the field work required has already been done by the Technical Advisory Committees, or is available from state agencies or the Soil Conservation Service. With adequate problem identification, Stage II of the Remedial Action Plan process can then propose the best management practices most appropriate to controlling the pollution problem. Many of the best management practices mentioned earlier have proven records of effectiveness in other parts of the Midwest and the Great Lakes region, and data on their effectiveness is available from the State Department of Agriculture.

The Remedial Action Plan process itself must be examined in terms of how it addresses nonpoint sources, specifically nonpoint sources from agricultural runoff. A list of participants of the Citizens Advisory Committee reveals that not a single agricultural producer, nor any related industries are included among the many industrial, commercial, environmental, or tribal groups. Among the County/City, State, and Federal agencies, departments, and services represented, the State Soil and Water Conservation Districts, and MPCA are the only link between agriculture and the Remedial Action Plan process. Noticeably absent are either Minnesota or Wisconsin State Departments of Agriculture, or representatives from the vast University of

Minnesota or Wisconsin Agricultural Extension network which has agents in each county of both states. Certainly extension agents from Carlton, St. Louis, and Douglas County would bring a wealth of information regarding current production methods that may be degrading water quality, as well as information on best management practices, including practices that are economically within a producers means, and those which will incur a cost greater than what the producer is willing to bear. While the USDA Soil Conservation Service (SCS) is listed as a participant, the extent to which they have participated is vague, leaving the impression that much of the information that the SCS could have brought to bear on problems of nonpoint sources pollution from all sources has not been included in the Stage I report.

Another trouble spot surfaced at a 29 December, 1992 meeting in the announcement by a representative from the MPCA that there was uncertainty whether the Wisconsin Department of Natural Resources would continue to participate in the Remedial Action Plan process.⁶⁰ MPCA representatives did not have concrete underlying reasons behind the move, but speculated that it may be connected to lack of cooperation with the State of Michigan in solving common water quality problems. This seems to indicate that States themselves may

⁶⁰ Meeting of the Citizen's Advisory Committee, St. Louis River Remedial Action Plan, City of Duluth, Minnesota, 29 December, 1992.

find it hard to coordinate water quality goals and Plan implementation. If cooperation between States, or differences in commitment between States cannot be solved, the many positive benefits of having a water quality plan which includes diverse interest groups will certainly be lost. Problems between States themselves or States and Provinces will only serve to preserve water quality status quo at best.

There are reasons that might explain why nonpoint source from agricultural runoff has received so little attention despite the obvious indicators, and why other instrumental agencies and services have not been involved up to this juncture, but none offer a reasonable rationale for ignoring nonpoint source pollution from agricultural runoff. The IJC did a complete review of the Stage I Plan for the St. Louis River basin in March, 1993. The overall evaluation of the Plan to this point by the IJC was very favorable.⁶¹ Despite IJC review, little attention has been focused on Articles VI (e)(i) through (ix) of the Great Lakes Water Quality Agreement of 1978, which speak specifically to agriculture, or the pertinent sections of the Great Lakes Critical Programs Act. In the absence of a focusing event, nonpoint source as a whole, and certainly nonpoint source pollution from agriculture has been left to the back burner.

⁶¹ Mr. Brian Fredrickson, Minnesota Pollution Control Agency, personal interview, 6 May, 1993.

VI: Conclusion:

The problem of nonpoint source pollution clearly exists in the St. Louis River basin. While no single program is the sole solution to pollution abatement, the Remedial Action Plan process, given strong leadership, clearly defined roles, and a commitment to community input that gives all interests a stake in the outcome is an ideal beginning. It certainly provides the kind of framework necessary for solving nonpoint source pollution problems from agricultural related runoff, and can address best management practices for individual producers.

The Remedial Action Plan process does, however, involve a great deal of coordination between states, states and provinces, and the U.S. and Canadian governments. Because of the many governmental linkages, added to the involvement of interest groups participating as part of the Citizen's Advisory Committee to the Remedial Action Plan process, stronger leadership may be required. The type of leadership necessary would need to come from the EPA, particularly if state governments cannot resolve differences in meeting Remedial Action Plan objectives. Stronger EPA leadership would also entail closer liaison between the IJC and the EPA in positively and affirmatively resolving conflicts, and facilitate meeting goals within individual Areas of Concern.

While the many players involved admittedly complicate the Remedial Action Plan process, this provides an

opportunity to draw on a wide variety of expertise. The opportunity is lost, however, when problem identification becomes too focused on a particular source, and key contributors are left out. This would appear to be the case in the St. Louis River Area of Concern in regard to nonpoint source pollution from agriculture. By not actively engaging such groups as the Minnesota or Wisconsin Departments of Agriculture, Agricultural Extension Service, or agricultural producers, much valuable information regarding a significant cause of nonpoint source pollution has been omitted from the Remedial Action Plan process. By their exclusion, producers become separated from water quality issues of which they have an interest, and an impact. If best management practices are identified and imposed upon agricultural groups which have been previously ignored or overlooked, they will likely be met with hostility, defeating any goal of improved water quality.

Along the Minnesota-Wisconsin coast of Lake Superior, the second largest tributary, the St. Louis River, with its high rate of sedimentation and turbidity, and high nutrient loading, continues to be plagued by symptoms of nonpoint source pollution, a good portion of which may be attributable to agricultural related activities. Reducing the adverse impacts on the environment from those activities requires knowledge about the various pollutants and how pollutant pathways can be interrupted. The problem is not new, nor is

it insurmountable. Much of the work necessary for identifying agricultural nonpoint source pollution, and the work needed to provide better management answers is available. While tackling a diffuse source presents a relatively more difficult task, the ability to do so exists. By addressing the problem and identifying solutions, the water quality of Minnesota's greatest water resource is improved, and preserved. Nonpoint source pollution from agricultural runoff must not be addressed in passing, but rather given the same level of attention as identified point sources.

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